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Novel concept of a dynamically adaptive EEG cap for dry electrodes

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Introduction

EEG acquisition using up to 256 conventional Silver/Silver-Chloride electrodes is a time-consuming process. Preparation, electrode positioning and tracking considerably increase patient stress. Hence, dry and preparation-free EEG is in focus of current biomedical engineering and medical research. This involves development of new cap systems in response to increased mechanical requirements. Our aim is an adaptive electrode positioning concept with sufficient capabilities for hair layer interfusion. An electrode-selective, impedance-controlled contact pressure minimizes electrode-skin impedance and ensures adaptation to local head morphology.

Methods

We propose a fluidic-driven, compliant mechanism which performs a helical motion when internal pressure is applied. A biocompatible silicone material was selected in order to comply with high medical safety requirements and standards. Furthermore, this enables risk-free long-term contact with human skin. The mechanisms were designed and parameterized using Finite Element Model simulations and are embedded into a compliant silicone network. The electrode-skin impedances are measured and used as input parameters for a superordinate control system. Subsequently, position and movement of every mechanism are controlled separately.

Results

The proposed cap allows for adaptive, compliant electrode adduction and positioning. A specific mechanism and electrode design enables interfusion of detaining layers of hair. The contact pressure of every electrode can be controlled separately and ensures stable contact with the scalp. Therefore, distinct thresholds for global and local electrode-skin impedance have to be defined and thus the internal pressures of the mechanisms are dynamically adjusted. This enables adaptive behavior of the cap to the individual head morphology as well as prevention of application of pressure to possible local skin lesions.

Conclusion

The proposed compliant cap concept for multichannel EEG enables fast, automated and comfortable adduction and positioning of biosignal electrodes. Thus, potential fields of application include improvement of EEG acquisition using novel dry electrodes as well as conventional Silver/Silver-Chloride electrodes.